Space Weather Technical Forecast

Issued on Monday, 12 February 2024 at 01:28 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrivals possible from late 12 Feb until early 14 Feb (day 1-3), with G1 Minor Storm intervals likely and a chance of G2 Moderate Storms. M-flares likely.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Moderate with a peak flare M1.0 from over the northeast limb at 11/2245 UTC. A number of C-flares were also observed, primarily from large region AR3576 located in the southwest quadrant, but also from AR3583, developing in the northeast disc and AR3582 developing in the north-centre disc. AR3576 remains the largest region, but has been losing small spots as it matures, although a small delta-spot has emerged to the north of the main leader spot, maintaining this region's complexity. AR3583 saw the most notable growth, with the development of strong leader and trailer spots, along with a number of smaller intermediate spots, while AR3582 had some small flux emergence occur to its north. There are eight regions currently on the disc, however all other regions are smaller and simpler. Two further regions are expected to soon rotate into view from the eastern solar horizon.

A couple of CME's were observed on available imagery, however these were all off the Earth-Sun line.

Solar Wind / Geomagnetic Activity: Solar winds showed the arrival of a CME at 11/0121 UTC, with the speeds measured by ACE and DSCOVR at L1, suddenly rising from background slow wind conditions of 370 km/s to be slightly elevated at 450km/s. A more gradual rise then occurred through the period, reaching elevated speeds of 550-600km/s by 12/0000 UTC. Density was mainly at or near average, but showed a brief and sudden jump to 47ppcc with the CME arrival, before falling again. Interplanetary Magnetic Field (IMF) Bt, suddenly rose to be strong after 11/0122 UTC to 16-20nT, then eased again at 11/0326 UTC to be Moderate 7-15nT, before easing to weak from 11/0600 UTC. The north-south component, Bz, became Moderate after 11/0122 UTC but variable in direction, between +15nT and -15nT, before gradually easing along with the total field strength. Phi angle was mainly negative (towards the Sun). Geomagnetic activity was Quiet to Active (Kp 1-4) with the strongest (Kp4) activity occurring 11/0000-0300 UTC.

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux was initially at the S1 Minor Radiation Storm level, but rose briefly after the CME arrival, to give a period of a S2 Moderate Radiation Storm 11/0210-0350 UTC peaking 134 pfu at 11/0315 UTC, before then declining through the rest of the day. This fell below the S1 level at 11/1805 UTC. GOES16 high energy (greater than 2MeV) electron flux remained at background. The associated 24-hour fluence was well below the Active (1e8 integrated pfu) threshold and has had a flat trend, with a 12/0000UTC fluence value of 1.55e6 pfu observed.

Four-Day Space Weather Forecast Summary

Solar Activity: Moderate activity likely to persist with further M-flares, and a slight chance of X-flares. These perhaps most likely from AR3576 in the southwest, but with an increasing potential from developing AR3582 and AR3583, along with new regions moving onto eastern disc.

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Solar Wind / Geomagnetic Activity: Multiple CME arrivals are possible day 1-2 (12-13 Feb) with ongoing effects likely day 3 (14 Feb). Otherwise current elevated winds are likely to gradually ease day 1 (12 Feb), before any CME enhancements occur. Any enhanced solar wind environment then easing day 4 (15 Feb). Mainly Quiet geomagnetic conditions at first are likely to become Active with a chance of G1 Minor Storms day 1, and likely rising to G1 Minor Storm with a chance G2 Moderate Storms day 2 (12-13 Feb). These conditions continuing day 3 (14 Feb) before easing to mainly Quiet day 4 (15 Deb).

Energetic Particles / Solar Radiation: GOES18 high energy (greater than 10MeV) proton flux is currently just below the S1 Minor Radiation Storm level. CME arrival later on day 1 and perhaps day 2 may result in a further brief periods above this level, however a general declining trend in flux is expected. Any further notable flares of AR3576, or potentially AR3575 from of the southwest limb, could also give further enhancements with flux rising above this level. High energy electron flux (greater than 2MeV) is expected to continue at background, with the associated 24-hour electron fluence remaining well below the Active threshold.

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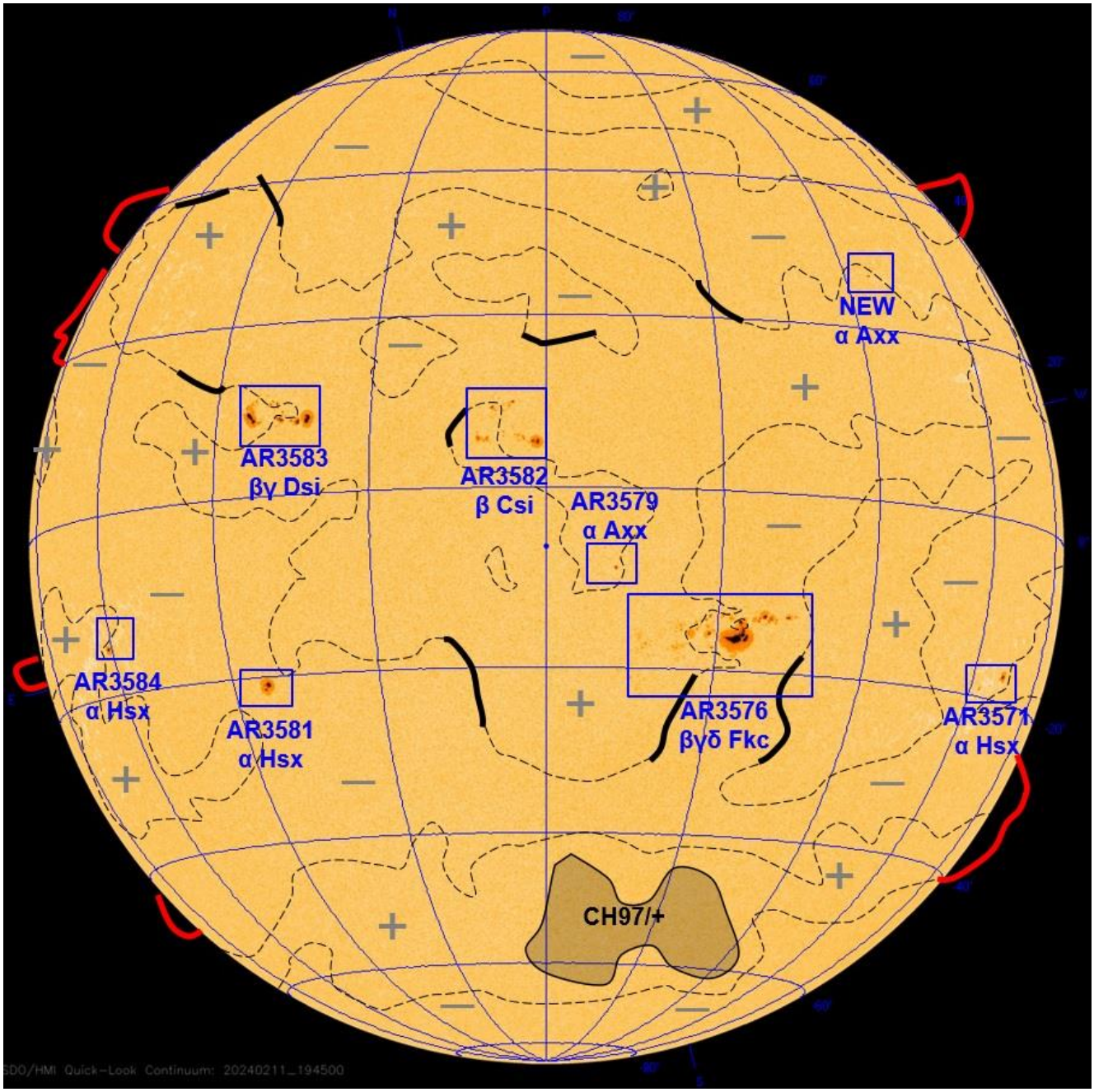
Figure 1. Solar Analysis Valid 11/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are three CMEs which may have Earth-directed impacts, and dominate the geomagnetic forecast for this period.

The first is a CME associated with the 08/2030 UTC south-centre filament eruption. This is modelled as crossing 1AU, mainly behind and below the Sun-Earth line late on day 1 (12 Feb) or early on day 2 (13 Feb). The second due the long period C-class flare of AR3579 and an associated filament eruption from 10/0700 UTC. This has been analysed as Earth-directed, possibly arriving during the first half of day 2 (13 Feb). These two CMEs may also combine to give a single arrival.

The third is from the AR3576 M9.0 flare 10/2100 UTC. This is a complex eruption near centre disc, resulting in a broad partial halo shock, but with the material appearing to be deflected mainly north-west. There is low confidence in the extent of any impact, with much of the material directed north and east, however this is likely to arrive later on day 2 (13 Feb), or early day 3 (14 Feb). Any arrival may combine with the previous impacts however, leading to further enhanced response.

Solar winds are then expected to gradually ease day 3 onward, and with CH96/+ to the far south, no coronal hole enhancements are expected in this period.

Initially Quiet geomagnetic activity with a chance of isolated Unsettled intervals as the influence of the CME arrival early on 11 Feb continues to ease. This becoming Active with a chance of G1 Minor Storm intervals, with the CME arrival late day 1 or early day 2 (12-13 Feb). Further CME arrivals on day 2 and into day 3 (13-14 Feb), bring a likelihood of G1 Minor Storm intervals and a chance of G2 Moderate Storms. Any combined impacts bring a slight chance of G3 Strong Storms. CME influence will then ease later day 3 onward (14 Feb), with activity becoming mainly Quiet with isolated Unsettled spells day 4 (15 Feb).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	25	60	40	1
Strong	G3	No	5	15	10	1
Severe	G4	No	1	2	1	1
Extreme	G5	No	1	1	1	1

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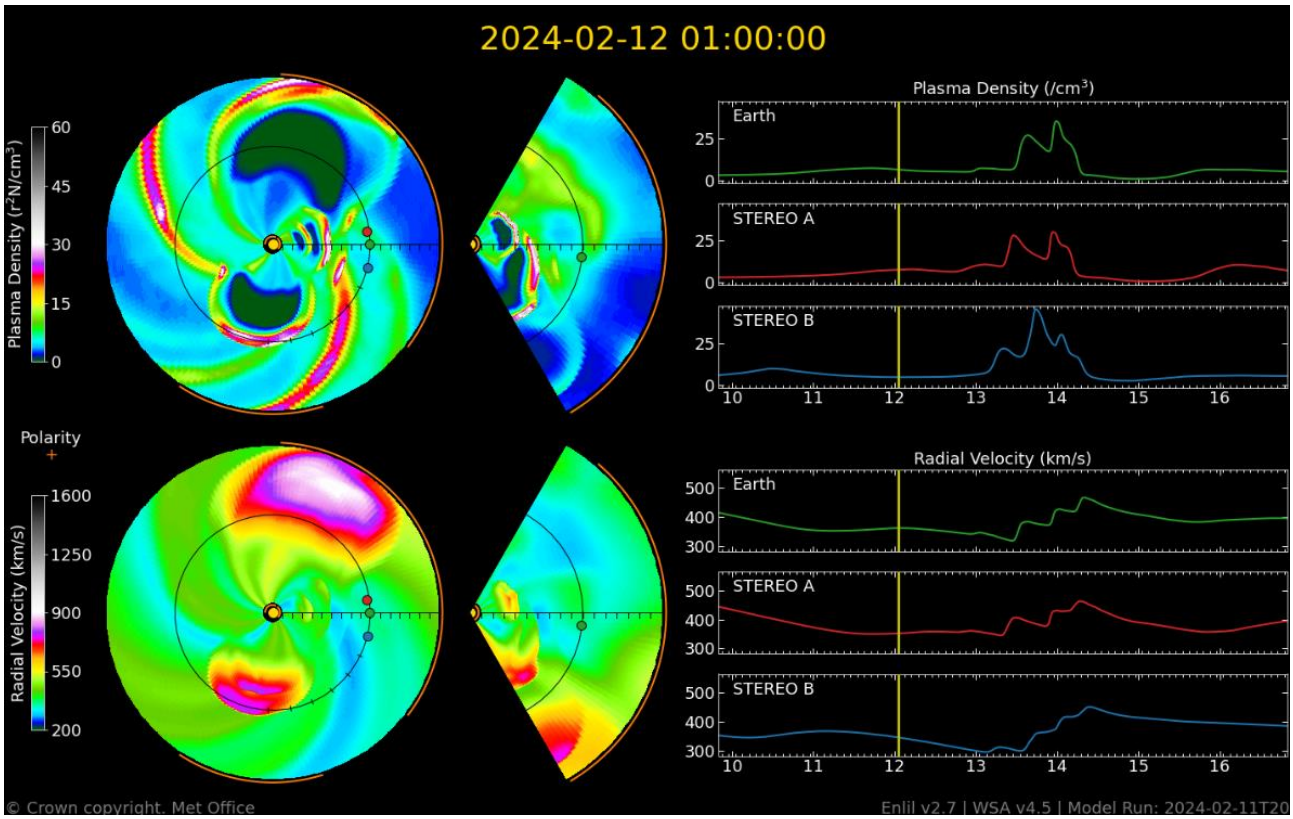
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
09/0113	Nil	Filament	S-centre	641 km/s	Late 12 Feb/early 13 Feb	Low confidence, mainly missing south
	Nil	Filament and C-flare AR3576	S-centre	890 km/s	Early 13 Feb	Mainly passing south.
11/0330	Partial Shock	M9 AR3576	SW, but directed NW	810 km/s	Late 13 Feb	Complex eruption – low confidence with material heading NE.

Figure 2: MOSWOC Enlil – Low confidence due to lack of CME arrival on 11 Feb currently in model.



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Radio Blackouts - X-Ray Flares:

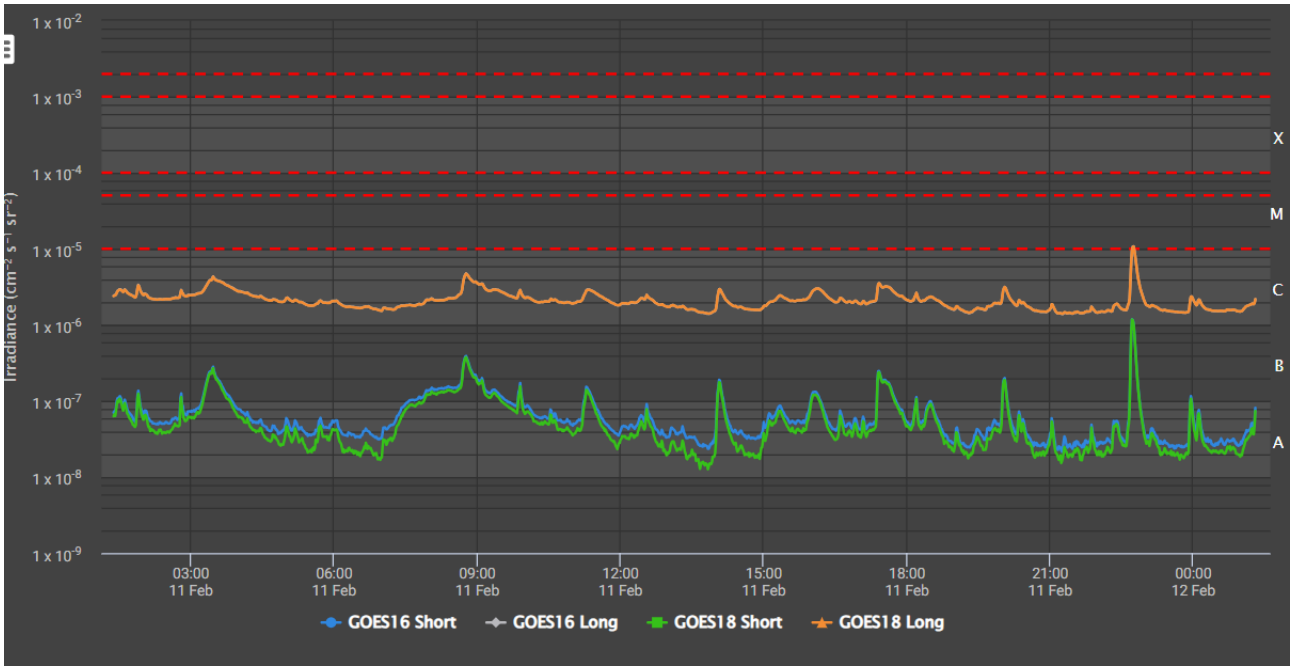
Mainly Moderate activity is likely to continue through the period, with eight sunspot regions currently on the disc, including the large but maturing AR3576, but also two further developing regions AR3582 and AR3583. There is a slight chance of X-class flares.

The declining trend of large region AR3576 appears to have stalled. This region is primarily comprised of negative polarity spots, however this maintains a complex structure due to a small positive polarity spot to the north of the large leader. Strong flares remain possible due to the strength of the magnetic flux of the main leader. Growth has been observed to the north of AR3582, near north-centre, and more notably in the intermediate region of AR3583 in the northeast, and these both have an increasing chance of notable flare activity.

New regions are also expected to soon rotate onto the east disc, with looping evident over both the northeast and southeast limbs, and one of these was the source of the M1.0 flare at 11/2245 UTC. These will also bring a risk of further M-flares.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	75	75	75	75
Very Active	R3 to R5 X Class	No	15	15	15	15

Figure 3: GOES 16-18 X-ray Flux



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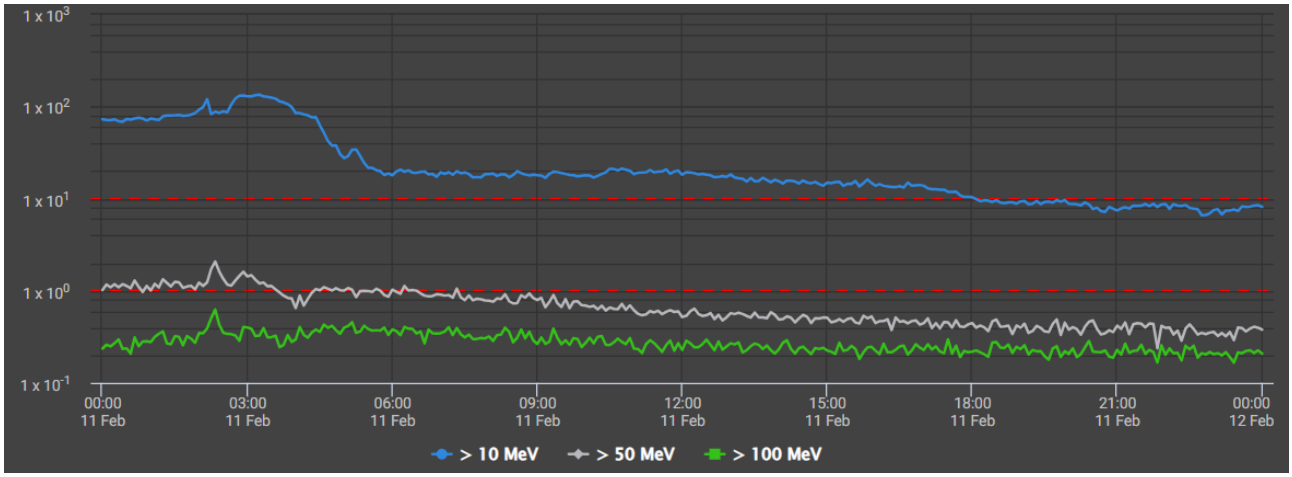
Solar Radiation Storms - (High Energy Protons):

GOES18 high energy (greater than 10MeV) proton flux continues to decline after the enhancement due to the X3.3 flare of AR3575 over the SW limb. This is now below the S1 Minor Radiation Storm level, and expected to continue gradually declining. A brief rise is possible on day 1 (12 Feb), however, ahead of any CME arrival. Furthermore, any further significant flares from AR3575 can still give some enhancement from over the limb, and while AR3576 is on a declining trend, any further M-flares or any X-flares from this region will also bring a slight chance of proton flux rising, especially as this region moves across the western disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	Yes	25	20	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: >10MeV >50MeV and >100 MeV GOES-18 Proton Flux



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High Energy Electrons Event (≥ 2MeV):

High energy electron flux (greater than 2MeV) as observed by GOES16 is expected continue at mainly background. There are no coronal hole enhancements forecast, however multiple CME arrivals will also likely disturb the Van Allen belts through day 1-3 (12-14 Feb). These may see some increased electron population, but will likely compress inside of GEO. As solar wind pressure eases later day 3 and more likely day 4, the Van Allen belts are likely to relax back to GEO. This may result in periods of Moderate, and a very slight chance of reaching High flux.

The associated 24-hour electron fluence is expected to remain well below the Active (1e8 integrated flux) threshold, as suggested by MOSWOC REFM, however this is likely to become less reliable through the period due to the arrival of a number of CMEs.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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